Technical University of Denmark

Insights from qualitative methodologies for R&D priority setting - experiences from the Nordic Hydrogen Foresight project

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Using Long Term Scenarios for R&D Priority Setting

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Scenarios in Energy - 1

- at least three understandings of scenarios in energy

- **Predictive scenarios**: (IEA - WEO)
  - Predicting the future - often using large computer based models
- **Explorative scenarios**: (Shell)
  - Debating futures, preparing for futures - a tool for imagining, analyzing, discussing, suggesting and preparing for sets of equally “plausible” futures
- **Normative or anticipative scenarios**: (Greenpeace)
  - Creating futures – visions, advocacy, policies.

Scenarios in Energy - 2

- scenarios in business: planning or communication tool ?

- Siemens Corporate Communication: Scenarios for 2020 www.siemens.com/horizons2020
  - customers and “the public”
- Siemens Corporate Technology: Scenarios on a 5-10 year horizon www.siemens.com/POF
  - customers and universities

Scenarios in Energy - 3

Some lessons learned energy scenarios and forecasting

- Scenarios and forecasts often reflect the interests of the organizations, governments or companies publishing the scenarios and forecasts
- Actors or groups of actors use energy model analyses as advocacy tools to legitimate certain energy futures
- Combination of modelling and politics: "*scientific negotiation of energy futures*" (Midttun & Baumgarten)
- The power of numbers: Energy scenarios often involves modelling to be able to quantify the outcomes in terms of costs, emissions and various other impacts
- Scenarios based on complex computer models are regularly criticized for not being any more comprehensive than simpler models

R&D priority setting

Quality

(history)

-publications

-impact factors

-quotations

-peer review

R&D priority setting

Relevance

(foresight)

-needs

-opportunities

-potentials

-stakeholders

Foresight Methods

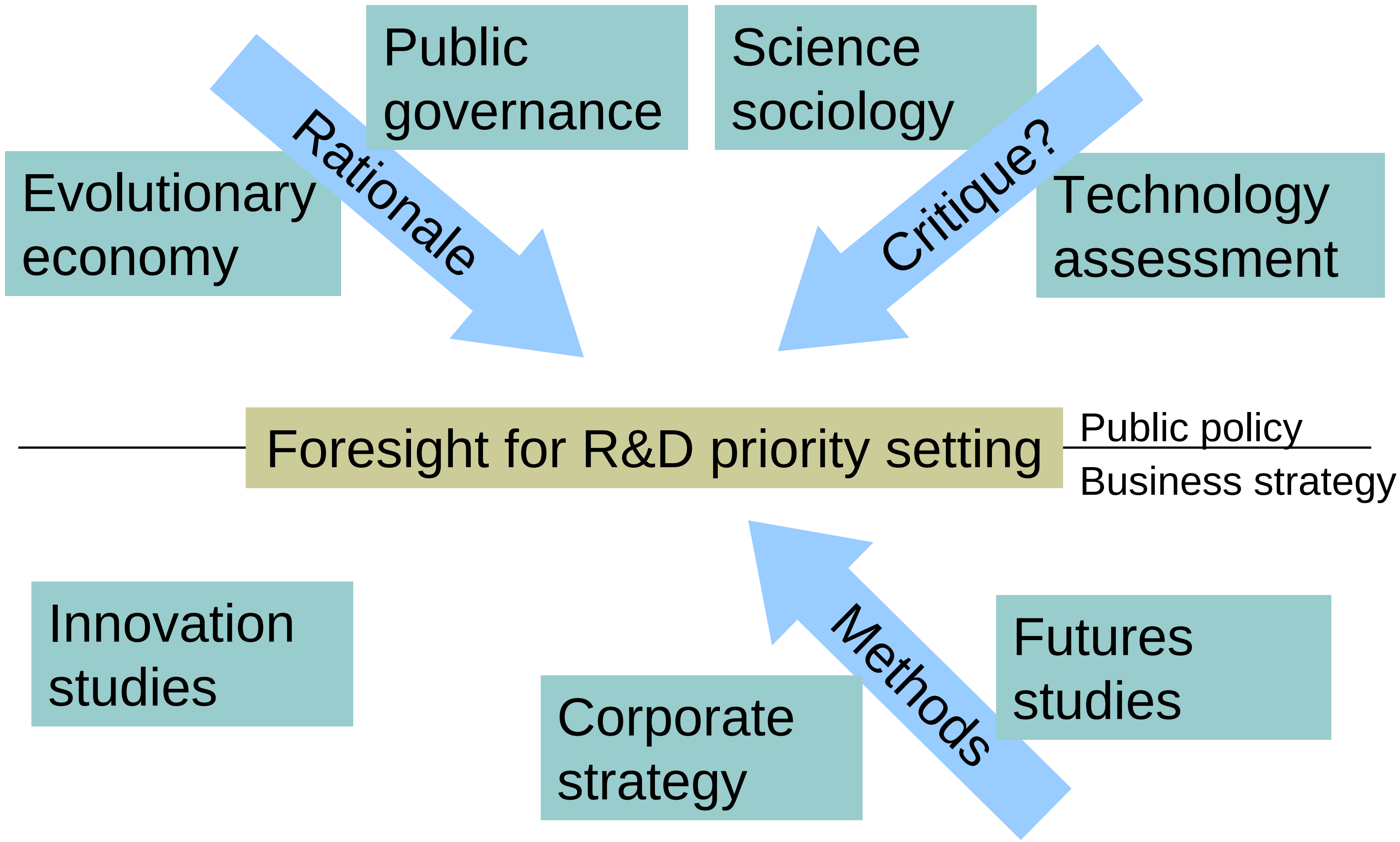
some qualitative methods for R&D priority setting

- More efficient meetings – not just “BOGAT – Bunch of Old Guys Around a Table”
- Expert panels / focus groups
- Delphi surveys – highly structured questionnaires
- Expert papers – highly structured
- Explorative scenarios and Visioning
- Science and Technology Roadmapping (backcasting)

- *Innovation analyses (understanding industrial dynamics)*
- *Policy measures (what is in the R&D policy tool-box?)*
- *Politics (understanding how decisons come about)*

Foresight for R&D Priority Setting

a field of practice - drawing on many fields of science



Qualitative Foresight Methods

- **Methods for technology foresight are developed from 1940s to 1970s. Key literature and text books are written in 1960s to 1980s and reflect:**
  - American experiences from defence and aerospace (i.e. Martino)
  - a linear model of innovation
  - experts point of view (elite scientists and industrialists)

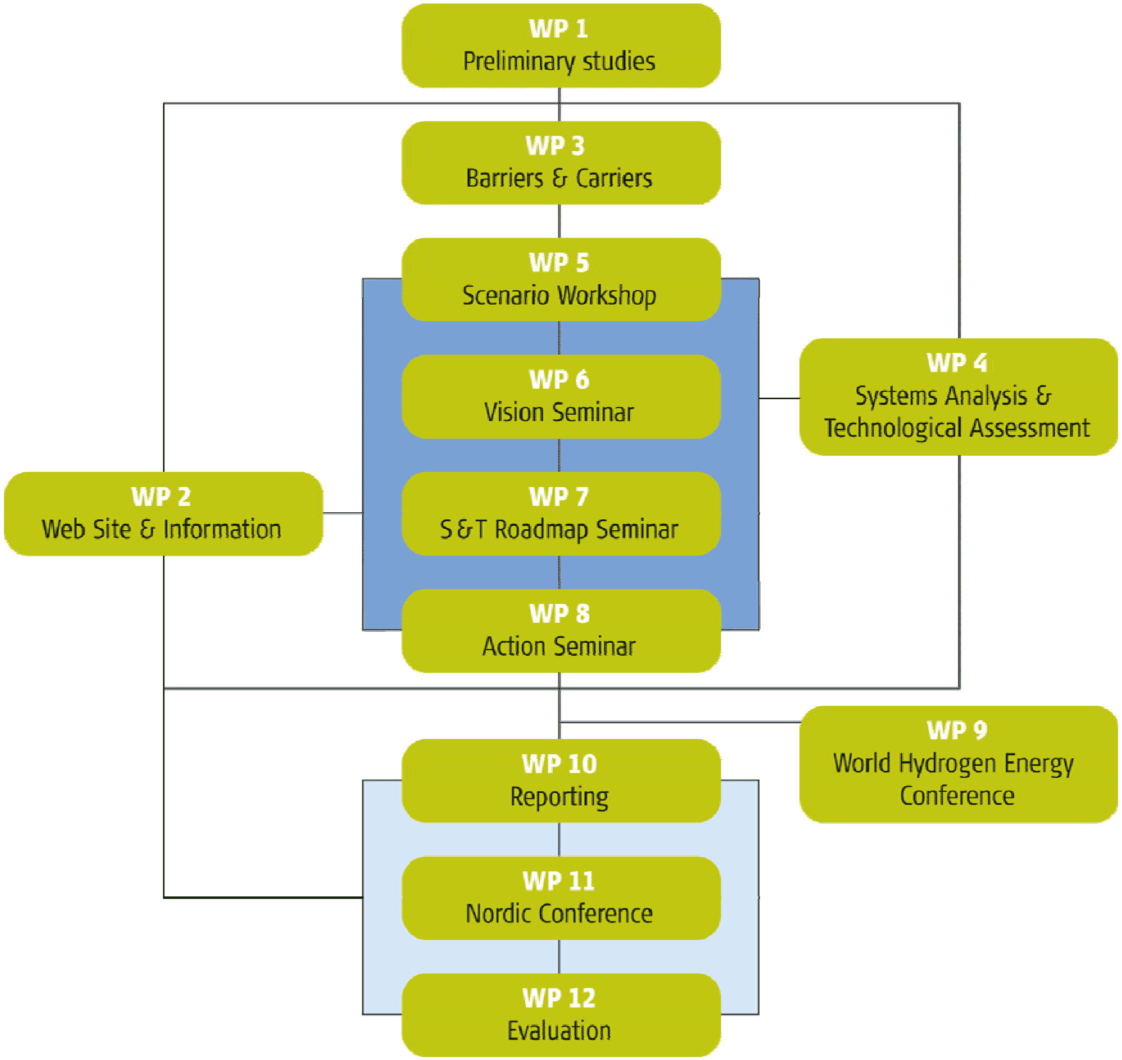
- **A new wave of application oriented theory and methodology literature is on is its way in this decade - reflecting:**
  - European experiences from national foresights in the 1990s
  - “the new science” (Mode 2, Triple-Helix, socially robust science)
  - mutual agenda setting between science, industry, government and “the public”
  - stronger link between the traditions of “systems of innovation” and “corporate strategy”

Nordic Hydrogen Energy Foresight
Some experiences

- **Partners**
  - 16 partners from R&D institutes, energy companies, industry, interests groupings
- **Timeframe**:
  - 1 January 2003 – 30 June 2005
- **Budget**
  - 730,000 EUR
  - 25% from Nordic Innovation Centre
  - 25% from Nordic Energy Research Programme

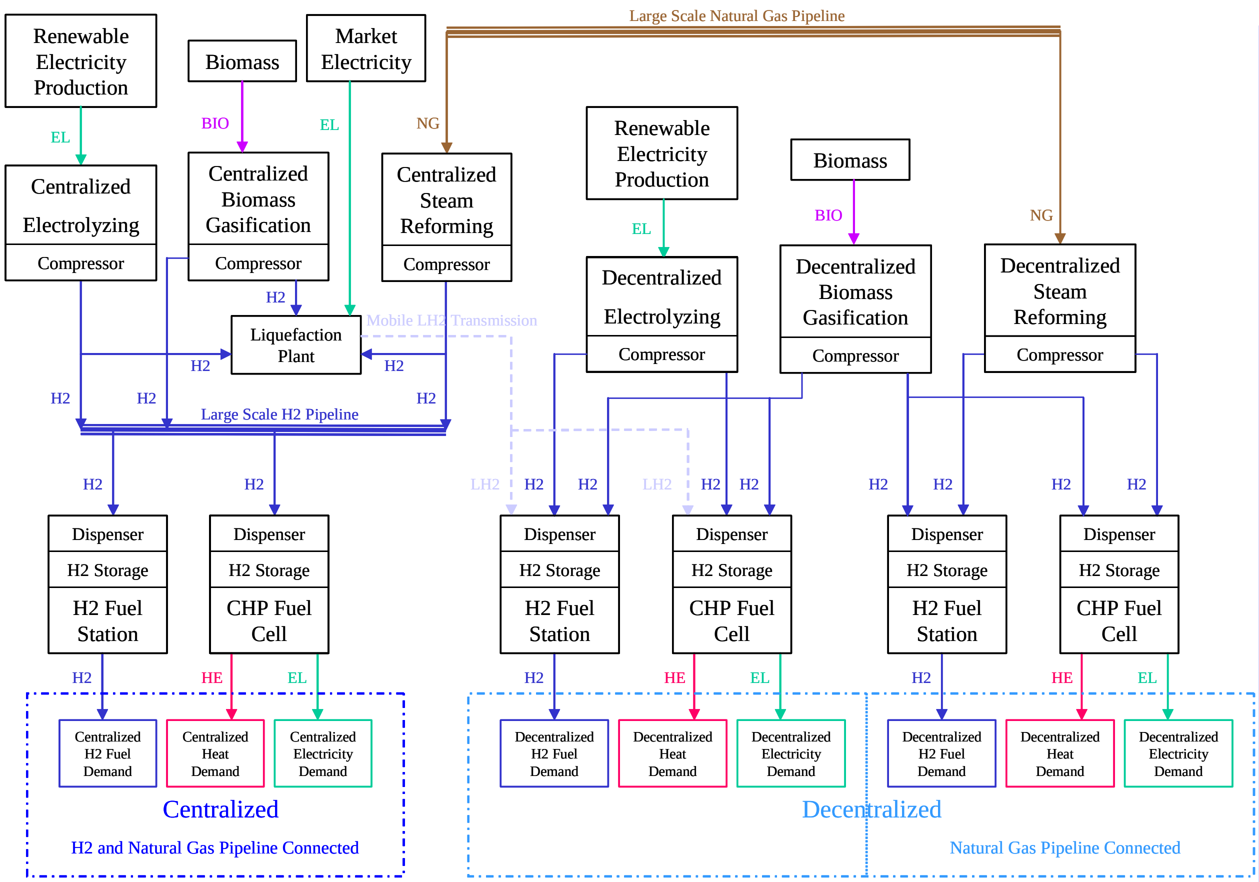
Nordic H_2 Energy Foresight

Project design



- Interviews & desk studies
- Interactive workshops
  - Scenario Workshop
  - Vision Workshop
  - Roadmap Workshop
  - *(Delphi-like survey)*
  - Action Workshop
- Modelling of the Nordic H_2 energy system
- Dissemination activities

Energy system modelling
the potential Nordic hydrogen energy system



A linear optimisation model with modular design

Calculates the least-cost alternative to achieve the given energy demand for hydrogen

Scenario Workshop
in Iceland

Analysing external driving forces and <u>strategic environment</u> for a future hydrogen society

Developments 2015-30 / External scenarios 2003-15	1. Hydrocarbon scarcity	2. Undisputable CO_2 problems	3. A smooth path to the future
B – Big Business Is Back			B3 Big vision 7%
E – Energy Entrepreneurs and Smart Policies	E1 Big vision 15%		
P – Primacy of Politics		P2 Big vision 18%	

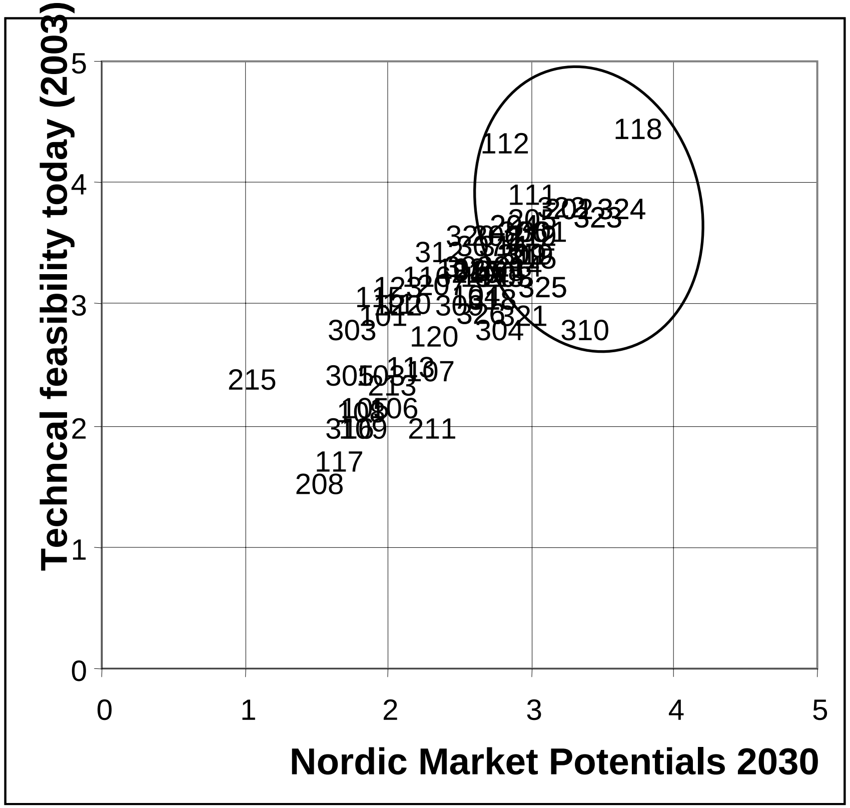
Three scenario sketches for Nordic H_2 introduction were produced

Estimate of H2's role in each scenario: at vision workshop

Vision Workshop in Sweden

Brainstorm on technical H2 visions

Ranking according to feasibility and market potentials



Wind power for H_2 production
H_2 from reforming of natural gas
Energy production from RE
Gasification of biomass
H_2 driven FC/electric city buses
H_2 FC/electric drives in new private cars
H_2 FC/electric drives for small special vehicles (fork-lifters, golf cars)
Pressurized tanks for H_2 in transport
Storage of H_2 as methane or methanol for transport
Methane driven FC/electric engines for ships
FC in fleets/public transport/taxi
Natural gas driven FC for domestic heat & power
H2 and FC in decentralized CHP plants

Roadmap Workshop in Denmark

<u>Timeline and sequence</u> of technical visions and possibilities

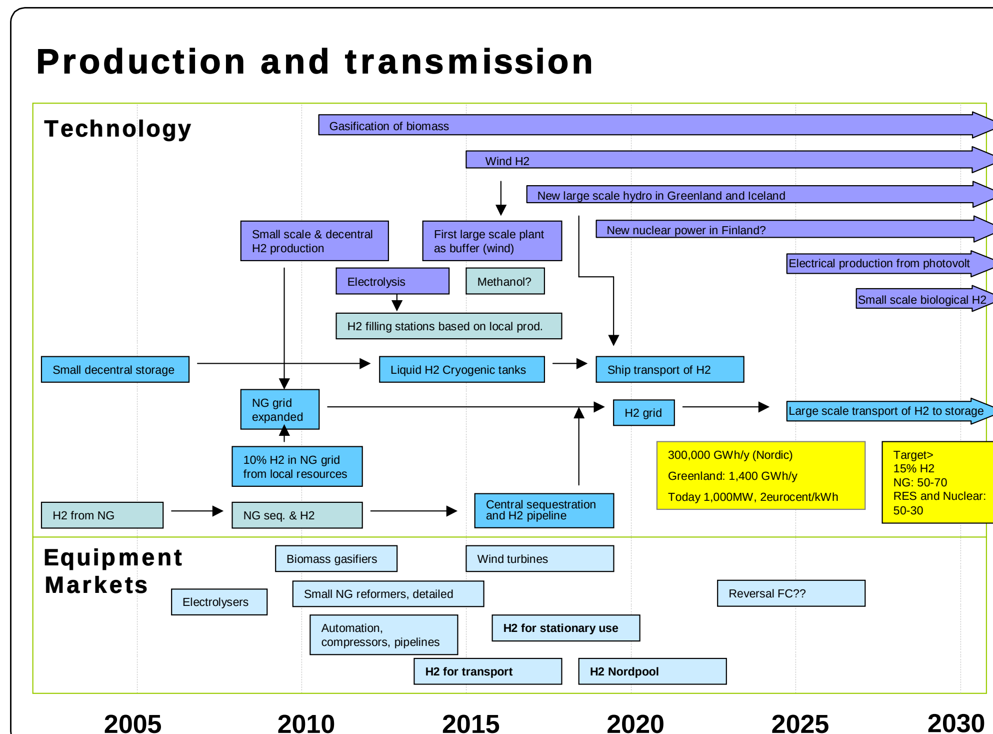
Identification of Nordic business opportunities

Scenario B3:

NG 70%, RES (and nuclear) 30%

Scenario E1 & P2:

NG 50%, RES (and nuclear) 50%



Roadmap Workshop
Nordic business opportunities

RISØ

	Production and Transmission	Transport	Stationary Use
Equipment Market	▪ Natural gas reformers ▪ Equipment for gasification of biomass (or biomass to biofuel) ▪ Equipment and systems technology to system integrate wind power with H2 production ▪ Electrolysers ▪ Infrastructure equipment; automation, compressors, pipelines In the longer term ▪ Equipment to long distance transport liquid H2 (cryogenic tanks, etc.) ▪ CO2 sequestration equipment	▪ Special vehicles ▪ Infrastructure equipment for hydrogen in transport sector ▪ APU systems for the transport sector (ships and trucks) – this links to similar systems for stationary use. In the longer term ▪ Marine use of hydrogen and fuel cells	▪ FC and FC systems for domestic CHP ▪ FC-based power back up and APU units ▪ FC APU units for remote power supply ▪ FC-based decentralised CHP systems
Energy markets	▪ Natural gas ▪ Biomass for energy ▪ Electricity from wind ▪ Other renewable energy sources In the longer term ▪ Operation of a H_2Nord Pool and trading with H_2 ▪ Ship transport of liquid H_2	▪ New fuelling infrastructure In the longer term ▪ Inclusion of transport and fuel production into emission trading during 2010.	▪ Stationary FC/ H_2 systems as a regulatory technology in energy systems with fluctuating production (i.e. wind power)

Links between the workshops and the model/simulating

Scenario workshop:

- Development of a number external scenarios, three of them (B3, E1, P2) were selected for further examination

Vision workshop:

- Hydrogen shares in 2030
- Technology visions

Roadmap workshop:

- Technology roadmaps up to 2030
- Potential Nordic niche areas
- Identification of barriers

Delphi study:

Action workshop:

- Major challenges in realising the visions
- Actions needed

Dissemination conference:

- Summary and recommendations

Fuel prices (E1<B3>P2)

Taxation (B3>E1, P2)

Investment subsidies (B3<E1, P2)

H2 demands (B3<E1<P2)

Sources for H2 (fossil B3>fossil E1, P2)

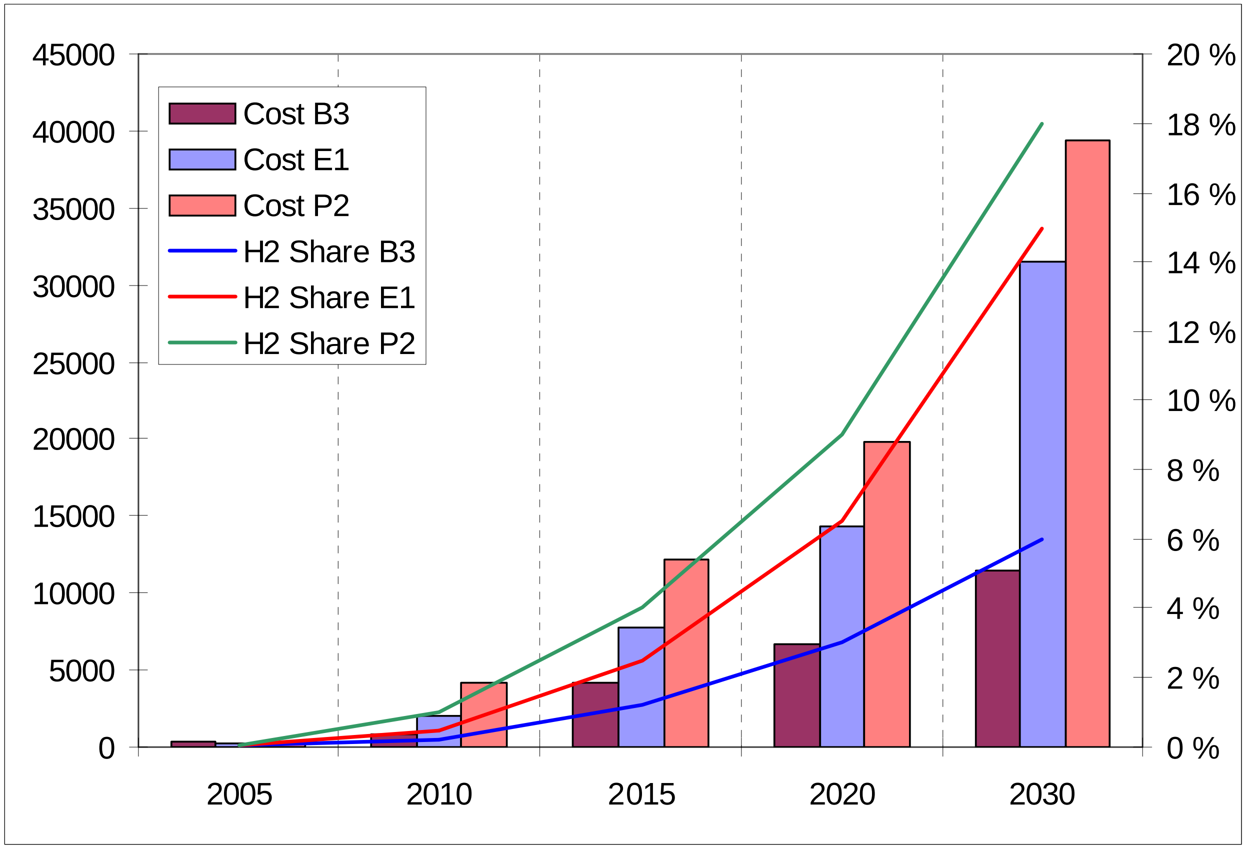
Technologies for distribution, transmission and conversion (influence parameters, input, etc.)

Timelines, Business opportunities

<= Scenario calculations

<= Sensitivity analyses

Example of model output



Total costs (in million €) for difference scenarios and hydrogen shares for the transportation sector

Action Workshop

Action recommendations were listed and categorized

1. **Information and awareness campaigns on hydrogen economy and innovation.**
2. **Closer Nordic co-operation on research and development** in strategically defined key areas and with adequate funding
3. **Demonstration projects**, **lighthouse projects and stimulation of Nordic niche markets** focusing on areas where Nordic industry has the best business opportunities
4. **International co-operation** and improving the Nordic impact on the international agenda setting

2. Nordic co-operation on R&D

R&D Priority setting - issues

- Intensifying R&D in areas with special Nordic potentials, including
  - New reforming technologies
  - More efficient electrolysis processes
  - Gasification of biomass and gas purification
  - New methods for hydrogen production using RES (e.g. photolytic production technologies)
  - New and efficient proccesses and technologies for CO2 capture from NG and storage
  - Fuel cell technology and material science
  - Small and medium scale hydrogen storage, incl. composite tanks
  - APUs
  - Industrial balance of plant components (BOP)
  - Distribution / infrastructure technology

2. Nordic co-operation on R&D

R&D Priority setting - measures

- Facilitating problem-oriented research
- Creating Nordic networks of excellence
- Carrying out adequate and mulitfaceted technology assessment studies and cost-benefit analysis
- Annual Nordic research summer schools hosted by alternating Nordic universities and with top Nordic and other Ph.D. students
- Mobility grants for Ph.D. students and researchers working in the field of hydrogen and fuel cell technologies and related fields.

3. Demonstrations, lighthouse projects and market stimulation

- Promoting a limited number of hydrogen demonstration communities:
  - Transport and stationary applications in an urban context
  - Stationary and transport applications in remote areas and islands
  - Marine use of hydrogen and fuel cells

- Stimulation of markets beyond demonstrations:
  - Incentives for decentralised energy systems and the use of RES (e.g. feed in tariff for FC)
  - Creating a common Nordic hydrogen energy market
  - Developing appropriate certification systems for hydrogen
  - Larger public procurement programmes of hydrogen applications and services.

Some lessons learned

RISØ

1. New & emerging technologies are in focus: lack of historical data & high uncertainty on future developments
2. Combining interactive workshops with quantitative analyses is a challenging task - but worth the effort
3. It takes considerable time to construct quantitative models and to gather the necessary inputs from the experts
4. Numbers and model output tend to catch the attention
5. When the participants have heterogeneous backgrounds it also takes time to develop mutual trust and a common language
6. Industry participants more open to quantitative methods than government planners
7. Cross-border foresight broadens the views and makes it possible to take up issues that might be overlooked at company or national level
8. Understand the innovation systems and political systems in which the results are to be used
9. Foresight exercise is a learning process – but who learn?

Additional information

Project homepage:

- www.h2foresight.info

Summary report (in English and Japanese)

- Dannemand Andersen, P., Holst-Joergensen, B., Eerola, A., Koljonen, T., Loikkanen, T. & E., Eriksson., E.A. (2005): Building the Nordic Research and Innovation Area in Hydrogen - Summary Report, January 2005. ISBN 87-550-3401-2.